TABLE OF CONTENTS

TABLES

FIGURES

1. INTRODUCTION

This Attachment was prepared in support of Excelsior Mining Arizona, Inc.'s (Excelsior's) Underground Injection Control (UIC) Permit application to the United States Environmental Protection Agency (USEPA). Excelsior is applying for an area Class III UIC permit to install a wellfield for in-situ recovery (ISR) of copper at the Gunnison Copper Project (Project), located in Cochise County, Arizona.

Attachments H-1, H-2, and H-3 were prepared to provide information regarding operating data for the ISR wellfield. This attachment contains the following background information and data in the order requested in the UIC instructions (EPA Form 7520-6):

- Average and maximum daily rate and volume of fluids to be injected;
- Average and maximum injection pressures;
- Nature of the annulus fluid; and
- A qualitative analysis and ranges in concentrations of all constituents of injected fluids.

2. DESCRIPTION OF OPERATIONS

2.1 Process Description

ISR will consist of blocks of injection wells and recovery wells constructed to circulate lixiviant throughout the mineralized bedrock and recover acid soluble copper from the ore body.

The wellfield will consist of injection and recovery wells interspaced approximately 71 feet apart in an alternating and repeating pattern. The arrangement of wells in the array will be designed to optimize recovery, based on geologic and hydrogeologic conditions observed during the installation of the wellfield. Aquifer testing will be performed at installation, and used to determine layout and number of recovery wells.

At the surface, copper will be removed from the extracted solutions at a solvent extraction-electrowinning (SX-EW) plant where pure copper cathode will be produced. During stage 1 operations, impoundments and the SX-EW plant at the nearby Johnson Camp Mine (JCM) will be used. An SX-EW plant and impoundments will be constructed during stages 2 and 3 at the Gunnison Copper Project (Project) site. After processing, the fluid will be recycled to the wellfield to begin the leaching cycle again.

The locations of the proposed facilities are shown on Figure H-1. Additional information regarding injection procedures is provided in Attachment K.

2.2 Injection Rates

Mining will be conducted in stages. Estimated production and duration of stages are provided below. The actual duration of each stage may change, based on operational and economic conditions.

Stage	Production (million lbs/year)	Years (estimated)**
Stage 1 (Pilot Phase)	25	1-10
Stage 2	75	11-13
Stage 3	125	14-20
Post-production rinsing	0	21-23

Injection rates and volumes will depend on a number of factors including:

1. The number of active injection wells (either in production, rinsing, or conditioning),
2. The rate at which the injection zone can accept lixiviant,

3. The rate at which recovery wells can be pumped.

Injection will include conditioning, leaching and rinsing operations. According to Excelsior's production schedule, there will be a total of 1400 Class III injection/recovery wells in the wellfield. The number of wells active at any one time will vary. Over the life of the Project, Excelsior estimates that the average injection rate will be 12,250 gpm or 17,637,500 gallons per day. The maximum injection rate is anticipated to be 26,800 gpm or 38,543,000 gallons per day. Estimated average and maximum injection rates during the Project stages are:

Stage	Estimated Average Injection Rate (gpm)	Estimated Maximum Injection Rate (gpm)
1 (estimated years 1-10)	5,300	6000
2 (estimated years 11-13	15,800	17,000
3 (estimated years 14-20)	25,600	28,000
Post Production rinsing	850	1,400

The actual field conditions encountered during operation will determine the pumping and injection rates. Compliance with a specific net volume or net rate of extraction in excess of injection is not proposed as a permit condition, as it is expected to vary depending on the block(s) being mined and rinsed.

The proposed permit conditions regarding injection flow are as follows:

- total injection, production, and hydraulic control volumes will be monitored and recorded daily;
- the 30-day rolling average of the total volume of injected fluids will not exceed the 30 day rolling average of the total volume of pumping from recovery wells and hydraulic control wells;
- an inward hydraulic gradient will be maintained around the active portions of the wellfield, as measured in observation wells located near the hydraulic control wells (Figure H-2).

3. INJECTION PRESSURE

Fracture gradient testing conducted in 2015 (29 packer tests in six formations) resulted in fracture gradients ranging from 0.78 to 2.22 pounds per square inch per foot (psi/ft). Details of the testing methodology and analyses are provided in Attachment I-2. Excelsior proposes a conservative maximum injection pressure gradient of 0.75 psi/ft to prevent hydraulic fracturing and propagation of existing fractures, to be measured daily.

4. NATURE OF ANNULUS FLUID

In recovery wells, the annulus fluid will be pregnant leach solution (PLS). In injection wells, the annulus fluid will be barren leach solution. In the fractured bedrock, the solution will be some intermediate composition between PLS and barren leach solution. Duke HydroChem prepared a report (Attachment H-2) that provides a brief description of each of the principal ISR solutions and an explanation of the process by which an estimated chemical composition of each was derived. Forecast compositions are summarized in Attachment H-2.

This section provides chemical characterization of the solutions at the Project that could be classified as “annulus fluids” including

- Barren Leach Solution (otherwise known as lixiviant);
- Raffinate;
- Pregnant Leach Solution (PLS);
- Makeup Water or Rinse Water (native groundwater);
- Rinsate Water from closure of the leached orebody; and
- Recycled Water.

Excelsior retained the services of Duke HydroChem, LLC (DHC) to use site specific data, data from the nearby Johnson Camp Mine (JCM), and current geochemical modeling software to forecast compositions of the process solutions expected for the Project (Attachment H-2). Data from metallurgical testing performed by SGS/Metcon of Tucson, Arizona, were used to augment data from the JCM raffinate sample (Attachment H-3). The material presented below is a summary of the detailed forecasting of process solutions contained in the Attachments H-2 and H-3.

4.1 The Evolution of the Process Solution Chemistry during Mine Operations

Sulfuric acidic solutions (barren leach solution) will be injected into the ore body via the injection wells. Copper will be recovered from the ore body according to the following circuit:

- an acidic solution (***barren leach solution or lixiviant***) will be applied (injected) to the ore body via injection wells,
- the acid in the barren leach solution will leach the copper from the copper ore, becoming ***PLS***,
- the copper-rich leach solution, PLS, will be recovered from the ore body via extraction (recovery) wells,
- the copper will be recovered from the PLS using SX-EW,

- the process solution that exits the SX-EW plant after copper recovery is termed ***raffinate***, and
- the raffinate will be re-acidified and re-injected to the ore body as ***barren leach solution*** to recover additional copper.

These ISR process solutions will be continuously cycled through injection and recovery for the duration of mining operations.

The compositions of the barren leach solution, PLS, and raffinate will evolve over time. Initially the barren leach solution will be composed of makeup water (native groundwater) acidified with sulfuric acid. With each injection and recovery cycle, the solutions will accumulate other constituents besides copper as the acidic barren leach solution reacts with the non-economic (gangue) minerals. After time, the barren leach solution will approach equilibrium with the gangue minerals in the ore body. At this point the process solutions in the cycle are considered to be "mature," e.g., mature raffinate, etc. The barren leach solution, PLS, and raffinate compositions presented in Table H-1 represent mature solutions and should be considered a forecast of the upper range of constituent concentrations.

Once a block of ore is leached of copper oxides (post-production ore block), the proposed closure strategy will be applied to the block. Rinse water (native groundwater) will be injected into the block in two stages, with a rest stage in between, until the water chemistry meets applicable Arizona AWQSs. The rinsing strategy is described in Attachment H-2.

4.2 Solution Characteristics

The forecast chemistries of the process solutions are presented in Table H-1.

4.2.1 Barren Leach Solution

As described above, the chemistry of the barren leach solution will evolve over the course of mine operations. The forecast barren leach solution composition will range from makeup water acidified with sulfuric acid to mature barren leach solution as the process solutions reach equilibrium with the gangue (non-economic) minerals (Table H-1).

The concentration end members of individual solutes are represented by the makeup water and the mature barren leach solution. Excelsior anticipates that the operational free acid content of the barren leach solution will be in the range of 5 to 15 grams per liter (g/L), but may be as high as 50 g/L for short periods of time. These ranges of free acid content were taken into account during geochemical modeling (Attachment H-2).

4.2.2 Raffinate

Because the Project is not yet operational, it is not possible to analyze actual mature raffinate from the site. The mature raffinate composition is based on analysis of a sample of mature raffinate collected from JCM, which is approximately one mile north of the Project. The details of the JCM mature raffinate composition are contained in the DHC 2015 report, including laboratory analytical reports (Attachment H-2). As described in Section 4.1, the composition of the raffinate will evolve over time, and constituent concentrations will increase until the composition is mature, i.e. the solution chemistry is in equilibrium with the gangue minerals in the ore block (Table H-1).

4.2.3 Pregnant Leach Solution and Recycled Water

The composition of the PLS will mature over time until the constituents in the barren leach solution come to equilibrium with the host rock minerals. Mature PLS (Table H-1) is composed of the same constituents as the mature barren leach solution plus additional copper. The anticipated operational copper grade of the Gunnison PLS is approximately 1.5 g/L (M3, 2014).

At the beginning of the leaching of a block of ore, the copper concentration may not meet the requirements of the SX-EW plant. In this case, the low-grade PLS (recycled water) will be re-acidified and reinjected into the ore body as barren leach solution. The reinjection of re-acidified recovered water will continue until the copper concentration of the PLS meets the operational requirements of the SX-EW plant. The composition of the recycled water cannot be determined until mining operations commence, but will contain much lower concentrations of the constituents than the mature PLS.

4.2.4 Makeup (Rinse) Water

When the copper is recovered from an ore block, the block will be subjected to the proposed rinse-rest-rinse closure strategy as described in Attachment H-2. The ore block will be rinsed with native groundwater (Table H-1) during both rinse periods. The estimated composition of the rinse water is based on analyses performed on a Project site sample collected May 13, 2015, from Excelsior hydrology test well NSH-006 (laboratory analytical report contained in Attachment H-2). The water chemistry analyses indicate that the native groundwater at the Project location meets AWQSs (Table H-1).

4.2.5 Rinsate Water from Closure of the Leached Ore Body

The rinsate will consist of a mixture of rinse water and PLS. The chemistry will evolve over time due to the three stages of the rinse-rest-rinse closure strategy:

- the early rinse will flush the majority of the PLS from the post-production ore block,
- the rest period will allow the solution pH in the post-production ore block to increase thereby removing metals from solution, and
- the late rinse period will flush remaining constituents to below Aquifer Water Quality Standards (AWQSs).

During the early rinse period, the rinsate will be directed to the SX-EW plant via the PLS pond until the rinsate consists of approximately 50 percent mature PLS. The forecast composition of the 50 percent PLS rinsate is presented in Table H-1. The rinsate will be routed to the evaporation pond for the remainder of the proposed rinse-rest-rinse strategy. The post-production ore block will continue to be rinsed until the water chemistry meets all AWQSs. The forecast composition of the final rinsate is presented in Table H-1.

4.2.6 Organics in Process Solutions

The process solutions (raffinate which in turn becomes barren leach solution and PLS) will likely contain detectable concentrations of organic compounds (extraction diluent and reagent). The amount that will be present is dependent on the design and operation of the processing facilities. Based on the Project team's experience with similar SX-EW projects, the total concentration of organic compounds is expected to be approximately 30 to 50 milligrams per liter total petroleum hydrocarbons .

TABLE H-1
Forecast Compositions of In-Situ Recovery Process Solutions, Gunnison Copper Project, Cochise County, Arizona

Analyte	Estimated Composition of Makeup Water or Rinse Water[a,b]	Sulfuric Acid (93.0 - 98.5 %)[b]	Forecast Composition of Mature Barren Leach Solution[b]	Forecast Composition of Mature Raffinate[c]	Forecast Composition of Mature Pregnant Leach Solution[b]	Forecast Composition of Initial Rinsate Solution to Evaporation Pond (50 % PLS)[c]	Forecast Composition of Groundwater After Block Proposed Rinse-Rest-Rinse Closure[b]	Arizona AWQS[d]
	(mg/l)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/l)
METALS								
Aluminum	<0.04	NR	8000	8000	8000	4000	<0.04	none
Antimony	<0.00019	0.05 - 0.5	<0.005	<0.005	<0.005	<0.005	<0.00019	0.006
Arsenic	0.002	0.1 - 4	<0.005	<0.005	<0.005	<0.005	0.002	0.05
Barium	0.1	NR	0.05	0.05	0.05	0.07	0.1	2
Beryllium	0.0003	NR	4	4	4	2	<0.000048	0.004
Cadmium	<0.000072	0.1 - 10	4	4	4	2	<0.000072	0.005
Calcium	50	NR	500	500	400	200	600	none
Chromium	0.006	1	1	1	1	0.5	0.005	0.1
Cobalt	0.00008	NR	20	20	20	10	0.003	none
Copper	0.01	0.2 - 0.5	150	150	1500	800	0.01	none
Iron	0.05	7 - 50	1000	1000	1000	700	<0.026	none
Lead	0.00009	0.1 - 10	0.005	0.005	0.005	0.003	<0.000031	0.05
Magnesium	10	NR	6000	6000	6000	3000	100	none
Manganese	0.007	0.05 - 1	1000	1000	1000	500	0.04	none
Mercury	<0.0002	1	<0.001	<0.001	<0.001	<0.001	<0.0002	0.002
Nickel	0.001	2	20	20	20	8	0.001	0.1
Potassium	1	NR	100	100	100	50	2	none
Selenium	0.003	0.1	0.05	0.05	0.05	0.03	0.002	0.05
Silver	<0.000021	NR	0.2	0.2	0.2	0.08	<0.000021	none
Sodium	30	NR	100	100	100	70	30	none
Thallium	<0.000026	NR	4	4	4	2	<0.000026	0.002
Zinc	0.9	1 - 2	800	800	800	400	0.8	none
ANIONS								
Alkalinity (mg/kg as $CaCO_3$)[e]	200	NR	<1.0	<1.0	<1.0	<1.0	6	none
Chloride	30	5 - 16	30	30	30	30	30	none
Fluoride	3	NR	900 - 1200	900 - 1200	900 - 1200	400 - 600	3	4
Nitrate (as N)[f]	2	5	5	5	5	4	2	10
Sulfate	20	965000	90000	90000	90000	40000	2000	none
WATER QUALITY PARAMETERS								
pH (s.u.)	7.5	-1.3	0.6 - 1.8	0.6 - 1.8	1.6 - 2.1	1.9	8.0	none
Total Dissolved Solids	300	965000	100000	100000	100000	50000	3000	none
RADIOLOGICALS								
Ra-226 + Ra-228 (pCi/L)[g]	0.4	NR	<1.3	<1.3	<1.3	<1.3	<1.3	5
Uranium	0.004	NR	1	1	1	1	0.003	none

Notes: mg/l = milligrams per liter; mg/kg = milligrams per kilogram; mg/kg as $CaCO_3$ = milligrams per kilogram as calcium carbonate; s.u. = standard units; NR = not reported

[a] Estimated makeup water composition based on analysis of Gunnison site groundwater (Well NSH-006, sampled 13 May 2015).

[b] Solute concentrations from Duke HydroChem LLC, 2016 (Attachment H-2)

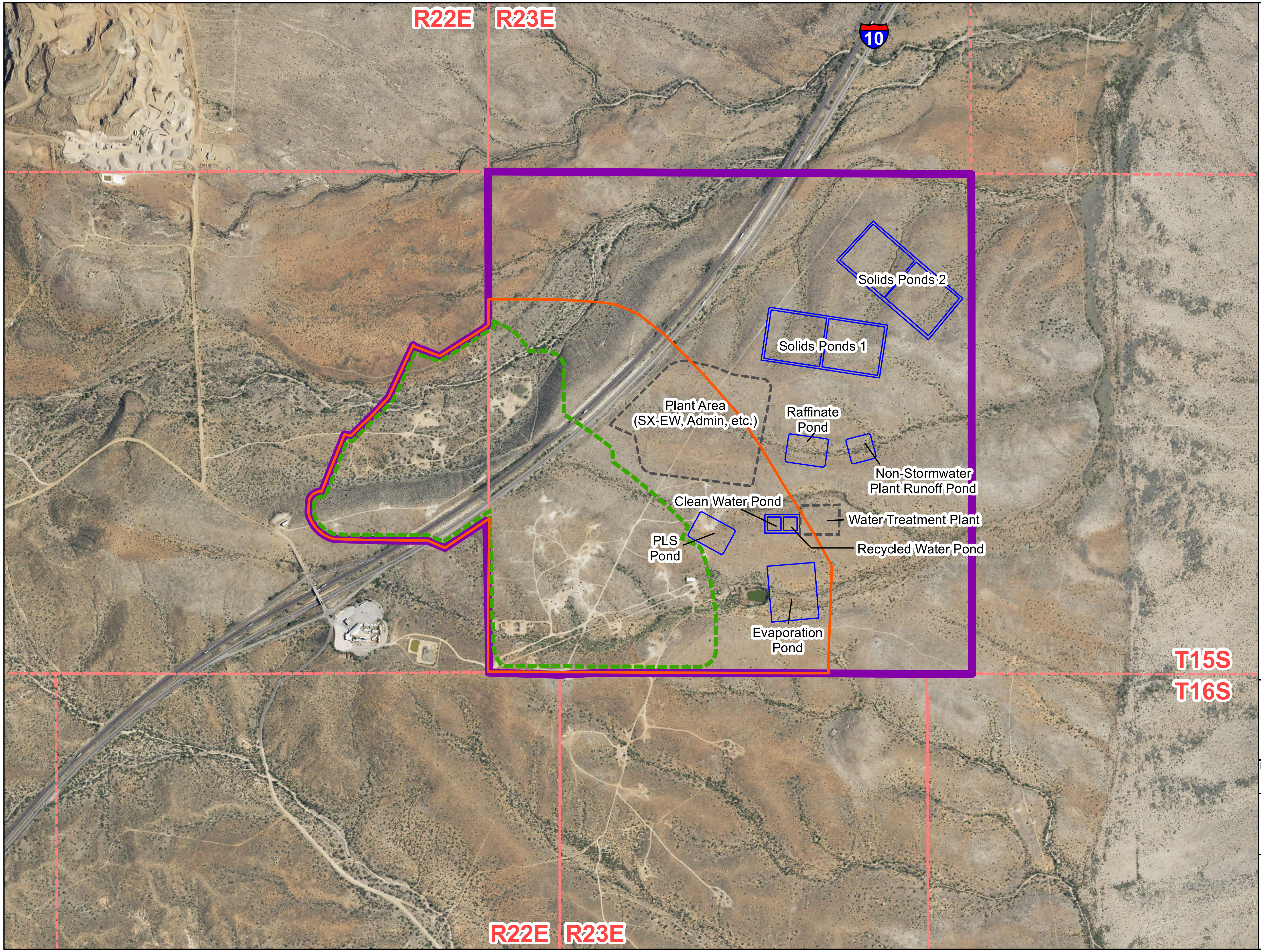
[c] Clear Creek Associates, 2016. Geochemical Modeling of Process Solution Evaporation and Solids Formation. January 2016.

[d] AWQS = Aquifer Water Quality Standards (Arizona Administrative Code R18-11-406)

[e] Alkalinity as equivalent calcium carbonate

[f] Nitrate as nitrogen

[g] Radium-226 plus radium-228 in picocuries per liter



Legend

- Gunnison Copper Project
- Wellfield
- Other Mine Structures
- Area of Review
- Pond

0 500 1,000 2,000
Feet

Excelsior Mining Arizona, Inc.
Gunnison Copper Project
UIC Permit Application
February 2016

Date	File ID
1/26/16	373-013C

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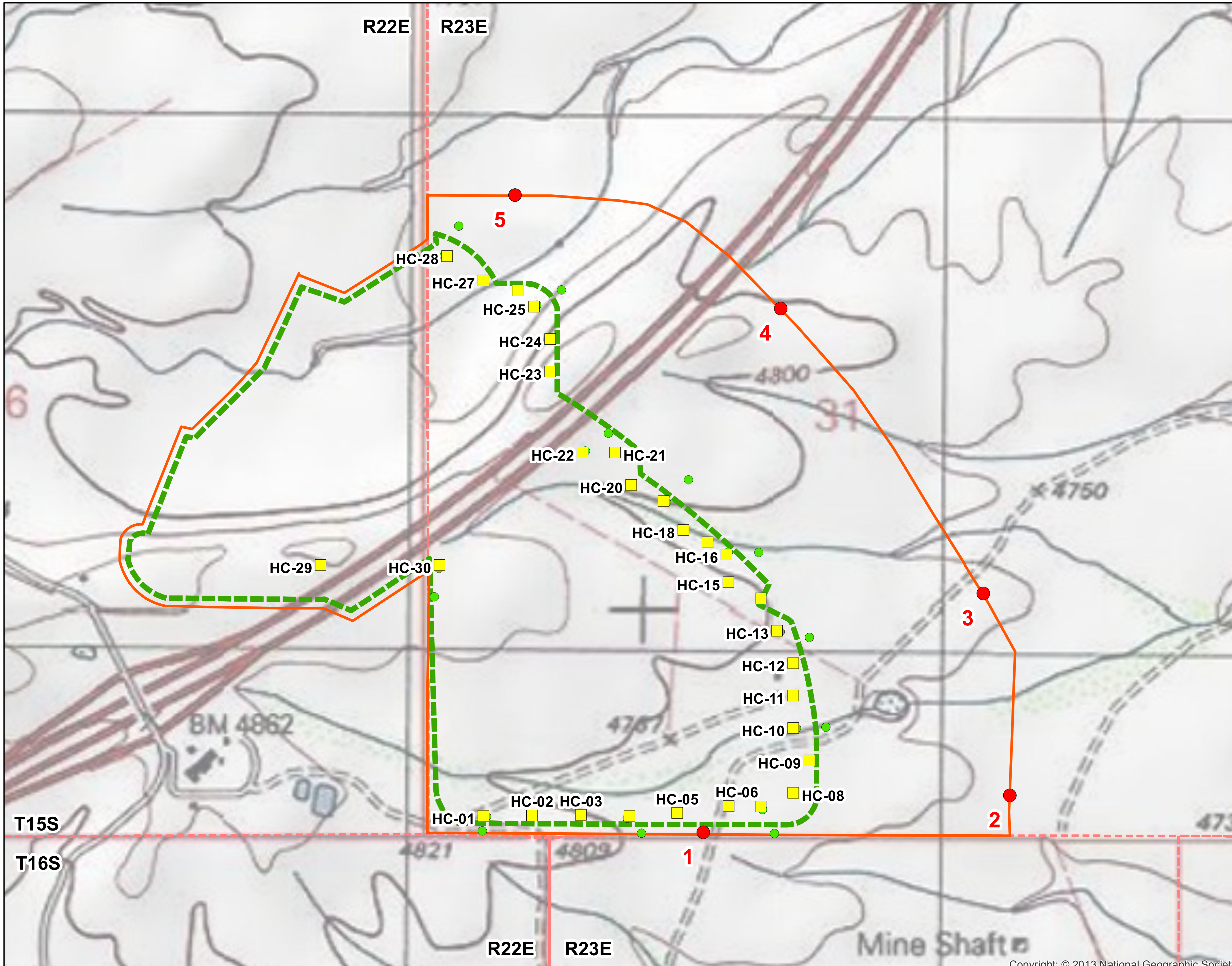
FIGURE H-1
Facility Site
Plan



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Legend

- POC-Wellfield
- Observation Well
- Hydraulic Control Well
- ISR Wellfield
- Area of Review

Observation Wells will have same number as associated hydraulic control well.

Example: At HC-1, observation wells will be named:

OW-1-I (inner)
OW-1-O (outer)

0 250 500 1,000
Feet

Excelsior Mining Arizona, Inc.
Gunnison Copper Project
UIC Permit Application
February 2016

Date	File ID
1/26/16	373-054

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FIGURE H-2
Area of Review, Point of Compliance, Hydraulic Control, and Observation Well Locations